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CASE REPORT

Severe hyperkalemia following blood transfusions: Is there a link?

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Abstract

Patients with gastrointestinal bleeding often require large volume blood transfusion. Among the various side effects of blood transfusion, the increase of potassium levels is a serious one which is often overlooked. We report a case of severe hyperkalemia in a patient with gastric bleeding after large volume transfusion of packed red blood cells. The patient had hyperkalemia at baseline associated with his receiving medication as well as acute renal failure following hypovolemia. The baseline hyperkalemia was further aggravated after massive transfusions of packed red blood cells in a short period of time. The associated pathogenetic mechanisms resulting in the increase of potassium levels are presented. A number of risk factors which increase the risk of hyperkalemia after blood transfusion are discussed. Moreover, appropriate management strategies for the prevention of blood transfusion associated hyperkalemia are also presented. Physicians should always keep in mind the possibility of hyperkalemia in cases of blood transfusion.

Key words: Hyperkalemia; Blood transfusions; Packed red blood cells; Renal function; Gastrointestinal bleeding

Core tip: Blood transfusion is associated with a wide range of potential complications. Among them, the increase of serum potassium levels is sometimes overlooked. Hyperkalemia is a potential deadly complication, especially when the patient has already increased potassium levels at baseline. A number of pathogenetic mechanisms associated with the development of hyperkalemia in patients receiving transfusions are discussed in the present case report. Moreover, the necessary precautions for minimizing the risk of transfusion-induced hyperkalemia are also presented.

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INTRODUCTION

Transfusion of red blood cells is associated with a wide range of potential complications[1]. These include mainly febrile non-hemolytic transfusion reactions, allergic reactions, transfusion-associated circulatory overload, infections, acute lung injury and hemolytic reactions[2]. An increase in serum potassium levels associated with blood transfusion is often overlooked[3]. Herein, we describe the case of a patient with massive hematemesis who manifested an aggravation of baseline hyperkalemia after large volume transfusion and discuss the underlying pathophysiology.

CASE REPORT

A 90-year-old patient was admitted to our hospital due to several episodes of hematemesis which were soon followed by hematochezia. He was currently receiving treatment with benazepril (20 mg/d) and hydrochlorothiazide (25 mg/d) for hypertension as well as tamsulosin (0.4 mg/d) for benign prostate hypertrophy. All these medications were discontinued following the patient's hospital admission. He had undergone partial gastrectomy (Billroth Ⅱ) 10 years ago due to a perforated peptic ulcer.

Upon admission he was hemodynamically unstable and normal saline was administered pending transfusion with packed red blood cells (PRBCs). Admission laboratory testing revealed anemia, acute renal failure and hyperkalemia (6.14 mEq/L) without indications of hemolysis (Table 1). The electrocardiogram showed sinus rhythm tachycardia without changes related to hyperkalemia. The patient was oliguric during the first 15 h of hospitalization. Arterial blood gases were consistent with metabolic acidosis (Table 1). Monitoring of hematologic, renal, electrolyte and acid base parameters was performed multiple times per day.

Within 12 h the patient required transfusion with 4 PRBC units which were already stored for 30 to 35 d. At the time of admission, the patient had lost and was continuing to lose large volume of blood and was therefore at a critical status. The need to rapidly and efficiently manage the hemorrhagic-hypovolemic shock mandated massive volume blood transfusion using the readily available at the time unwashed PRBC units. Management of hyperkalemia consisted of intravenous administration, in parallel with the transfusions, of a solution made by combining 1 Lt 5% dextrose in water (D/W 5%) together with 15 IU fast acting insulin. The above solution of glucose and insulin was selected in order to both achieve a rapid decrease of potassium levels as well as minimize the risk of hypoglycemia in a patient already at a critical status. When the patient was hemodynamically stable, he underwent an emergency endoscopy which revealed a large ulcer at the site of the anastomosis without active bleeding at the time.

Following blood transfusions, the patient quickly restored normal diuresis and blood pressure. However, potassium further increased to a maximum of 6.97 mmol/L on day 2. This suggests that the aggravation of hyperkalemia was associated with the rapid massive transfusion rather than the initial oliguria and renal impairment. The administration of the D/W 5% with insulin solution was continued and serum potassium levels gradually decreased to normal (Table 1). As a result, no additional measures to reduce potassium levels were required. On day 3 a relapse of gastric bleeding occurred and the patient required another blood transfusion with a total of 7 PRBC units (which were also already stored for 30 to 35 d) as well as with fresh frozen plasma. However, this time the transfusion of the 7 PRBCs was done over a much greater period (4 d) instead of the initial rapid transfusion of the first 4 PRBCs, which were administered in only 12 h. No further increase in serum potassium was observed. Thereafter, the patient had an uneventful recovery and was discharged after 15 d with normal serum electrolyte concentrations.

DISCUSSION

There is evidence that transfusion of PRBCs can lead to increased potassium levels, especially in cases of large volume transfusion[4]. This was an interesting case of a patient with massive gastric hemorrhage and hyperkalemia at baseline which was aggravated following PRBCs transfusion.

Persistent hyperkalemia is observed only when urinary potassium excretory capacity is reduced due to renal failure, effective circulating volume depletion or more commonly hypoaldosteronism[5]. However, increased potassium intake and movement of potassium from cells into extracellular fluid may also play a prominent role in the pathogenesis of hyperkalemia[5]. Causes of increased potassium intake include a rapid intravenous infusion, the administration of potassium penicillin mainly as an intravenous bolus, the ingestion of a KCl containing salt substitute or potassium supplements and the use of stored blood for transfusions[6].

Hyperkalemia evident upon admission could be due to the coexistent prerenal azotemia associated with oliguria and subsequently decreased potassium excretion[5]. In fact, volume depletion leads to decreased glomerular filtration rate and increased proximal sodium and water reabsorption. As a result, there is a marked decrease of fluid and sodium delivery to the distal nephron, leading to a decreased potassium secretion[7]. This impairment in renal potassium excretion is counterbalanced by the hypovolemic-induced secondary aldosteronism. However, in our case the simultaneous administration of benazepril impairs the synthesis

Table 1 Patient's parameters during hospitalization

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 10	Day 16	Normal ranges
Ht (%)	26.4	22.9	19.7	23.3	26	26.9	31.4	33.7	
Hb (gr/dL)	8.5	7.7	6.7	8.3	9	9.2	10.8	10.8	
PRBCs	4	2	2	2	1	0	0	0	
Cre (mg/dL)	1.53	1.73	2.12	1.81	1.43	1.41	1.34	1.22	0.6-1.2
Ure (mg/dL)	97	136	190	158	102	74	45	38	11-54
K^+ (mEq/L)	6.14	6.97	5.65	4.69	4.21	4.08	4.12	4.84	3.5-5.3
Na^+ (mEq/L)	140	140	141	138	141	142	140	143	136-146
Glc (mg/dL)	178	129	90	94	121	119	87	107	70-125
pH	7.32	7.35	7.36	7.42	7.45		7.5		
HCO_3 (mEq/L)	13.7	15.8	16.8	21.1	23.3		22.1		
pCO_2 (mmHg)	27.6	29.2	30.3	33.2	34		28.8		

To convert hemoglobin from gr/dL to gr/L multiply by 10; to convert serum creatinine from mg/dL to μmol/L multiply with 88.4; to convert serum urea from mg/dL to mmol/L multiply by 0.357; to convert serum glucose from mg/dL to mmol/L divide with 18. Ht: Hematocrit; Hb: Hemoglobin; Cre: Creatinine; Ure: Urea; PRBCs: Packed red blood cells received at the specific day.

of angiotensin Ⅱ and therefore aldosterone, thus contributing to the profound hyperkalemia observed at patient's admission. It has been suggested that impaired potassium entry into cells observed in patients with hypovolemia can also lead to increased potassium levels[7].

Hyperkalemia may contribute to the pathogenesis of the patient's coexistent metabolic acidosis at baseline by suppressing ammoniagenesis in the proximal tubules and decreasing medullary thick ascending limb $NH4^+$ transport, which in turn decreases medullary accumulation of ammonium[8]. As a result, hyperkalemia can decrease ammonium excretion, which is the major component of net acid excretion by the kidneys. Even though acidosis can directly increase potassium levels by both redistribution of potassium out of cells (in cases of mineral acidosis) and by decreased potassium secretion in distal tubules[5], in the present case the mild degree of acidosis is not a major factor for the pathogenesis of hyperkalemia.

The patient had restored normal diuresis and normal blood pressure 15 h after admission. Despite the improvement of blood pressure, diuresis, the continuous administration of D/W 5% plus insulin solution as well as the discontinuation of benazepril, a further increase of potassium levels was observed. Acute renal failure is associated with hyperkalemia when it is accompanied with low urine flow, oliguria and therefore low sodium delivery to the distal tubule, leading to decreased renal potassium excretion. However, in our case the patient had restored normal diuresis. As a result, it is less likely that the observed hyperkalemia is a consequence of acute renal failure. As a result, this aggravation of hyperkalemia can be attributed to the initial rapid transfusion of PRBCs rather than a hypovolemic state. The patient also received transfusion of additional 7 PRBCs between days 2 and 5 of hospitalization. However, these transfusions were not accompanied by further elevation of potassium levels. This can be attributed to the much greater period over which these transfusions took place.

The use of stored blood for transfusions is followed by an increase of serum potassium levels[9]. Indeed, a prospective study showed that potassium levels increase more pronounced in patients who receive blood stored for more than 12 d[10]. In fact, potassium is gradually released from red blood cells of the stored blood, resulting in an extracellular potassium concentration that by 21 d can reach up to 30 mEq/L in whole blood and up to 90 mEq/L in PRBCs[9]. Furthermore, the lysis and destruction of red blood cells, especially in the transfusion of older PRBCs, can further increase potassium levels[3]. In addition, the significantly decreased blood volume of our patient at baseline in combination with the high volume transfusion would make him more susceptible to potassium levels elevation from the PRBCs transfusion[3]. Indeed, the patient's circulating blood volume had been markedly reduced after the gastric hemorrhage and thus its capacity to dilute exogenously loaded potassium was limited.

The risk of potassium overload can be minimized by selecting only blood collected less than 5 d prior to transfusion and by washing any unit of blood immediately before infusion to remove extracellular potassium[11]. Furthermore, the use of potassium absorption filters during transfusion may also decrease potassium loading[12,13]. Moreover, factors that also play a role in the increase of potassium levels are the rate and volume of transfusion as well as the patient's circulating pre-transfusion blood volume.

All things considered, hyperkalemia should be not overlooked in patients receiving large volume blood transfusions. A high level of suspicion and prompt management is warranted by the physician.

COMMENTS

Case characteristics

A patient with large volume blood loss due to gastrointestinal bleeding presented requiring emergency mass blood transfusion.

Clinical diagnosis

An aggravation of baseline hyperkalemia was observed after massive blood

transfusion in short time.

Differential diagnosis
Hyperkalemia associated with: Massive blood transfusion or acute renal failure.

Laboratory diagnosis
Baseline hyperkalemia associated with the patient's medications as well as hypovolemia was further aggravated after massive blood transfusions.

Imaging diagnosis
The patient underwent endoscopy which revealed a large ulcer at the site of a previous gastric anastomosis.

Pathological diagnosis
Hyperkalemia following massive blood transfusion in short time.

Treatment
Intravenous administration of a solution consisting of dextrose in water (D/W 5%) together with fast acting insulin, discontinuation of the angiotensin converting enzyme inhibitor that patient was receiving and restoration of blood volume in order to improve renal function.

Related reports
Hyperkalemia following blood transfusion is a complication which is sometime overlooked and can lead to fatal complications especially in patients of critical condition as is often the case in the emergency department.

Term explanation
PRBC: Packed red blood cells.

Experiences and lessons
Hyperkalemia is a sometimes overlooked but serious complication of blood transfusion, especially in patients with comorbidities and comedications that predispose to higher baseline potassium levels.

Peer-review
This is a good case, well managed, well written, and discussed.

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